

REMARKS

Claims 2 - 26 are pending in this Application. No amendments to the Claims have been made in this Response.

In the Office Action:

- (a) Claims 2-23, 25 and 26 have been rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 2,717,867 issued September 13, 1955 to Jewell et. al.; and
- (b) Claim 24 has been objected to as being dependent upon a rejected base Claim, but has been indicated to be allowable if rewritten in independent form including all of the limitations of the base Claim and any intervening Claims.

It is respectfully submitted that the rejection of Claims 2-23, 25 and 26 is overcome by the remarks that follow.

Independent Claim 26

Independent Claim 26 is as follows (underlining and bolding added):

26. A process for converting a liquid feed material into a vapor phase product comprising the following steps:

- (a) providing a fluid bed comprising solid particles and a fluidizing medium, **wherein providing the fluid bed is comprised of introducing the solid particles to the fluid bed at an upstream horizontal position in the fluid bed**, wherein providing the fluid bed is further comprised of introducing the fluidizing medium to the fluid bed so that the fluidizing medium is moving in a substantially vertical fluidizing direction, and wherein the solid particles are at a conversion temperature which is

suitable for facilitating the conversion of the liquid feed material to the vapor phase product;

(b) moving the solid particles in a substantially horizontal solid transport direction from the upstream horizontal position to a downstream horizontal position;

(c) **introducing the liquid feed material directly to the fluid bed, separately from the solid particles** and separately from the fluidizing medium, **at a feed zone located between the upstream horizontal position and the downstream horizontal position** in order to facilitate the conversion of the liquid feed material into the vapor phase product;

(d) maintaining the solid particles as fluidized solid particles in the feed zone by introducing the fluidizing medium to the fluid bed in the feed zone; and

(e) collecting the vapor phase product.

The Office Action dated December 24, 2008

On page 4 of the Office Action dated December 24, 2008, the following acknowledgement is made:

“Jewell does not disclose “introducing the liquid feed material *directly* to the fluid bed...at a feed zone located between the upstream horizontal position and the downstream horizontal position.”

As noted above by underlining and bolding, these limitations are explicitly claimed in independent Claim 26.

Notwithstanding this acknowledgement, the Examiner has indicated as follows on pages 5 and 6 of the Office Action:

1. “Therefore, Examiner finds Applicant’s limitation specifying introduction of the liquid feed material “directly” to the fluidized bed to be of no patentable consequence because Jewell does explicitly disclose introducing the liquid feed material “directly” into an aerated mass of solid particles. Examiner notes that a fluidized bed is no more than a fluidized (or aerated) mass of solid particles. Thus, Examiner is unable to discern any patentable distinction over Jewell with respect to Applicant’s recitation for “direct” introduction of the liquid feed material into the “fluidized bed.””
2. “Finally, Examiner finds Applicant’s limitation specifying introduction of the liquid feed material at a (separate) location between an upstream horizontal position and a downstream horizontal position to be of no patentable consequence because the mere rearrangement of parts of a prior art device generally cannot serve as the basis for establishing patentability in the absence of new or unexpected results (see MPEP § 2144.04(VI)(C)). In this regard, Examiner notes that Jewell discloses wherein the liquid feed material (17) is introduced at a feed zone location that is located between the foremost upstream end of the fluidized bed and the foremost downstream end of the fluidized bed (see Jewell, Fig. 2).”

It is respectfully submitted that the limitation: “introducing the liquid feed material *directly* to the fluid bed...at a feed zone located between the upstream horizontal position and the downstream horizontal position...” as is explicitly claimed in independent Claim 26 represents a fundamental distinction between the Applicant’s invention and the teachings of Jewell et al which is not rendered unpatentable by the teachings of Jewell et al and which is of patentable consequence.

This fundamental distinction and its technical significance is described in the remarks which follow.

Exhibits

The following documents are attached as Exhibits to this Response:

Textbooks

- Exhibit 1: Raseev, Serge, "Thermal and Catalytic Processes in Petroleum Refining", Marcel Dekker, Inc., 2003, pages 179-188 (from Chapter 4) and pages 269-274 (from Chapter 5);
- Exhibit 2: Smith, J.M., "Chemical Engineering Kinetics", Third Edition, McGraw-Hill Book Company, 1981, pages 182-191 (from Chapter 4);
- Exhibit 3: Fogler, H. Scott, "Elements of Chemical Reaction Engineering", Prentice-Hall, Inc., 1986, pages 10-20 (from Chapter 1) and 28-37 (from Chapter 2);
- Exhibit 4: Kunii, Daizo, Levenspiel, Octave, "Fluidization Engineering", Second Edition, Butterworth-Heinemann, 1991, pages 211-225 (from Chapter 9);

Papers

- Exhibit 5: Brown, Wayne, Pinchuk, R., Monaghan, G., "Benefits from Coking of Heavy Feedstocks", Petroleum Technology Quarterly, Vol. 10, No. 4, 2005, pages 85-91;
- Exhibit 6: Mekler, Valentine, Schutte, A., Whipple, T.T., "Continuous-Coking Process Shows Ability to Handle Heavy Feed Stocks", The Oil and Gas Journal, November 16, 1953, pages 200-203;

Presentations

- Exhibit 7: Kamienski, Paul, Gorshteyn, Anna, Phillips, Glen, Woerner, Andrew, "Delivering Value for Resid and Heavy Feed", 1st Russia & CIS Bottom of the Barrel Technology Conference, Moscow, April 19, 2005;

Exhibit 8: Rooijmans, Aad, "FLEXICOKING at Esso Rotterdam", dated October 6, 2003, downloaded from the Internet on June 1, 2009 at the following link: http://www.tnw.tudelft.nl/live/pagina.jsp?id=4aeeed0c-d9f3-4bfd-b9b1-27ec3c4a9f1&lang=en&binary=/doc/exxonmobil_2003.pdf; and

Other

Exhibit 9: Ellis, Paul J., Paul, Christopher A., "Tutorial: Delayed Coking Fundamentals", AIChE 1998 Spring National Meeting, New Orleans, LA, March 8-12, 1998;

Exhibit 1 provides, in Section 4.2.3, an overview of coking processes used in petroleum refining, including fluid coking (pages 179-184), FlexicokingTM (pages 184-186), and moving bed or LR coking (pages 186-188). Exhibit 1 provides, in Section 5.3.5, a description of design elements for fluid coking units. Of particular note is the description in the first three paragraphs on page 269, which state as follows:

"Backmixing that occurs in the dense phase fluidized bed is very intensive and the reactor and coke burning bed approach a perfectly mixed reactor. Kinetic calculations must take this into account.

Backmixing also has as a result the homogenization of the temperature inside the dense phase fluidized bed. The difference between different points of the bed does not exceed 1-2°C.

The reactor and the heater in coking and flexicoking plants use dense phase fluidized beds..."

Exhibit 2 provides, in Section 4-7, a comparison of stirred-tank (i.e., well mixed flow) and tubular-flow (i.e., plug flow) reactors. Of particular note are Figure 4-15 and Figure 4-16, and the accompanying description of these Figures on pages 184-186. As indicated in Figure 4-15, longer residence times (i.e., greater reactor volumes) are required for a stirred-tank reactor to achieve a conversion rate which is comparable to a tubular-flow reactor, and conversion rates exceeding about 80 percent are not easily achieved with stirred-tank reactors. As indicated in

Figure 4-16 and described on page 185, at conversions of 70 percent or larger, more than twice as much reactor volume is required for a stirred-tank unit than for a tubular-flow unit.

Exhibit 3 provides, in Section 1.4, an overview of continuous-flow reactors, including continuous-stirred tank reactors (Section 1.4.1 on pages 10-11), and tubular reactors (Section 1.4.2 on pages 11-15). Exhibit 3 provides, in Chapter 2 (pages 28-37), an overview of design elements for both continuous-stirred tank reactors and tubular reactors. Of particular note is Section 2.3 (pages 33-37), which provides examples for sizing both a continuous-stirred tank reactor and a tubular reactor, and which demonstrates in Figure E2-1.1, Figure 2.2 and the accompanying description of these Figures on pages 34-36 the increased reactor size as a function of conversion for a continuous-stirred tank reactor in comparison with a tubular reactor.

Exhibit 4 provides, in Chapter 9, an overview of mixing characteristics in fluid beds. Of particular note are Example 1 (page 218) relating to the determination of a vertical dispersion coefficient (D_{sv}) in a shallow coarse particle bed, and pages 220-222 relating to the determination of a horizontal dispersion coefficient (D_{sh}) in a fine particle bed of fast rising bubbles. As can be seen, the values for D_{sv} on page 218 have an order of magnitude of 10^{-1} , while the values for D_{sh} on page 220 have an order of magnitude of 10^{-3} , illustrating that vertical mixing in a fluid bed occurs at a much higher rate than does horizontal mixing.

Exhibit 5 provides (in a paper written by the Applicants) a description of the features and advantages of the Applicants' invention as claimed in independent Claim 26 in comparison with fluid coking and delayed coking processes, in the context of many of the principles which are documented in the Exhibits.

Exhibit 6 provides an illustration of the effect of operating temperature of a continuous coking process upon the yield and quality of liquid products produced by the process. Of particular note is Table 2 and the accompanying description on page 202 which indicates that the production of non-liquid products, including both coke and non-condensable gases (i.e., C₃ and lighter) decreases as the operating temperature is reduced, resulting in a corresponding increase in the production of gasoline and gas oil (i.e., liquid) products.

Exhibit 7 provides an overview of the fluid coking process and the FlexicokingTM process in comparison with the delayed coking process.

Exhibit 8 provides an overview of the FlexicokingTM process as performed at Esso Rotterdam.

Exhibit 9 provides an overview of the delayed coking process, which is NOT a fluid bed process but which is referred to in other Exhibits. Exhibit 9 is therefore included solely to provide background for the delayed coking process in the context of the references in the other Exhibits to the delayed coking process.

Plug Flow and Well Mixed Flow

Referring to Exhibits 2-3 and Exhibit 5, in chemical engineering terms, “plug flow” is a term which is used to describe movement of a fluid in which there is no back-mixing between the individual components of the fluid. In the context of a plug flow fluid bed reactor, plug flow exists where each discrete volume of fluidized solids or “plug” which is introduced into the feed end of the reactor passes through the reactor to the outlet end with no mixing with the discrete volumes of fluidized solids or plugs which are upstream or downstream. As a result, all of the material in a particular plug which is introduced into a plug flow fluid bed reactor will spend exactly the same time in the reactor and will be subjected to exactly the same conditions while passing through the reactor.

In contrast, and referring to Exhibits 1-3 and Exhibit 5, “well mixed flow” is a term which is used to describe movement of a fluid in which the back-mixing between the individual components of the fluid is complete and fully efficient. In the context of a well mixed fluid bed reactor (such as a continuous stirred tank reactor or “CSTR”), well-mixed flow exists where all of the material which is introduced into the reactor is instantaneously mixed completely with the material which is already present in the reactor. As a result, not all of the material which is introduced into a well mixed fluid bed reactor will spend the same amount of time in the reactor, since a significant fraction will exit the reactor immediately upon being introduced into the reactor.

In well mixed flow, each discrete volume of fluidized solids which is introduced into the reactor is instantaneously mixed with each of the other discrete volumes of fluidized solids which are present in the reactor so that the contents of the entire reactor are homogeneous. In plug flow, each discrete volume or plug of fluidized solids which is introduced into the reactor becomes well mixed so that each plug is homogeneous, but adjacent plugs are not mixed with each other.

Well mixed flow occurs when the rate of mixing of fluidized solids in a reactor is high relative to the rate of passage of the fluidized solids through the reactor. Referring to Exhibit 4, the rate of mixing in a fluid bed in the vertical direction is typically several orders of magnitude higher than the rate of mixing in a fluid bed in the horizontal direction.

Well mixed flow may therefore be associated with reactors in which the fluidized solids move vertically through the reactor, since this vertical movement will encourage vertical mixing between adjacent volumes of fluidized solids. Well mixed flow may also be associated with other reactor configurations where intimate mixing of the fluidized solids is promoted. In contrast, plug flow may be associated with reactors in which the fluidized solids move horizontally through the reactor, so that mixing between adjacent volumes of fluidized solids is minimized.

Hydrocarbon thermal upgrading processes based upon well mixed flow type fluid bed reactors are known. One particular such process is the “fluid coking” process, which is described at page 3, line 33 to page 5, line 20 of the Specification, and in Exhibit 1, Exhibit 5 and Exhibits 7-8. The related FlexicokingTM process is described in Exhibit 1 and in Exhibits 7-8.

In the fluid coking process and the FlexicokingTM process, a vertically oriented fluid bed reactor is used so that the fluidized solids move vertically through the reactor (see Exhibit 1, Figure 4.25; Exhibit 7, pages 8 and 14; Exhibit 8, page 12). Solid particles are introduced into the reactor in the freeboard region above the fluid bed and are removed from the bottom of the reactor. Liquid feed material is sprayed into the fluid bed at several different

elevations where it coats the fluidized solid particles. The nature of vertical solids movement and mixing in the fluid bed leads to generally well mixed conditions. As a result, some solid particles and thus some liquid feed material will “short circuit” the reactor and thus be removed from the reactor immediately, while other solid particles and thus some liquid feed material will spend a very long time at reactor conditions.

A consequence of “short circuiting” in a well mixed flow type fluid bed reactor is that a portion of the liquid feed material is lost with no liquid products (i.e., products which are a liquid at ambient temperature and pressure) being derived therefrom.

To minimize such losses, and as described in Exhibits 2-3 and Exhibit 5, the reactor volume may be increased substantially in order to dilute the incoming liquid feed material, thereby increasing the average residence time of the liquid feed material in the reactor and reducing losses. In commercial applications, a fluid coking reactor is typically sized at approximately 15-20 times larger than would be required if the reactor did not produce well mixed conditions.

Alternatively or additionally, the operating temperature of the reactor may be increased in order to increase the rate at which conversion (i.e., reaction) of the liquid feed material occurs. However, as described in Exhibit 6, increasing the operating temperature will result in reduced yield of liquid products from the liquid feed material and reduced quality of the liquid products which are produced.

As a result, in designing a well mixed flow type fluid bed reactor, a balancing act must be performed to seek an acceptable compromise between the processing capacity of the reactor and the yield and quality of the liquid products which are produced in the reactor.

In hydrocarbon upgrading applications, fluid bed reactors are typically sized to provide a target conversion rate of at least 99 percent of the liquid feed material. Because of the limitations described above which are associated with well mixed flow type fluid bed reactors, a well mixed flow type fluid bed reactor which is the same size as a plug flow type reactor capable of achieving a 99 percent target conversion rate will experience significant losses of unreacted

liquid feed material so that the actual conversion rate of the well mixed flow type fluid bed reactor will be well below the target conversion rate. To compensate, the designer of a well mixed flow type fluid bed reactor has three options.

The first option is to increase the size of the well mixed flow type fluid bed reactor by up to 20 times in order to provide more time for reactions to occur in the reactor, which will result in significantly increased capital cost.

The second option is to increase the speed of the reactions which occur in the well mixed fluid bed reactor by increasing the operating temperature of the reactor. However, as mentioned above, increasing the operating temperature of the reactor will reduce both the yield of liquid products produced from the liquid feed material and the quality of the liquid products which are produced from the liquid feed material.

The third option is to increase both the size and the operating temperature of the well mixed flow type fluid bed reactor in order to achieve an acceptable compromise between the capital cost of the reactor and the yield and quality of the liquid products.

With any of the three options described above, the limitations associated with a well mixed flow type fluid bed reactor result in design constraints in a hydrocarbon upgrading process which can be reduced or eliminated if a plug flow type fluid bed reactor is used.

In particular, a plug flow type fluid bed reactor can be sized and operated to achieve a desired capacity or throughput of the reactor, and an operating temperature of a plug flow type fluid bed reactor can be selected to optimize the yield and quality of the liquid products which are produced from the liquid feed material, without consideration of the effects and consequences of back-mixing.

Comparison of Independent Claim 26 and Jewell et al

Jewell et al describes a two stage coking process which is carried out on a preheated residual liquid oil from a fractionating tower (15).

In the first stage of the coking process, hot coke particles are mixed with the preheated residual liquid oil in a vaporizing section of a coking zone, under conditions such that the relatively vaporizable portion of the residual oil is rapidly vaporized and the unvaporizable portion is absorbed by the hot coke particles (column 3, lines 35-41 of Jewell et al).

In the second stage of the coking process, the hot coke particles containing absorbed residual hydrocarbons from the vaporizing section are introduced into a soaking section of the coking zone, which includes a drum (19) containing a fluid bed (21) so that the coke particles are precipitated onto the fluid bed (21) (column 5, lines 14-24 of Jewell et al). Sufficient residence time of the coke particles is provided in the fluid bed (21) to complete the coking of the residual hydrocarbons which are absorbed onto the coke particles (column 5, lines 35-40 of Jewell et al).

The first stage of the coking process (i.e., the vaporizing section of the coking zone) is described extensively at column 3, line 35 to column 5, line 13 of Jewell et al, and is interchangeably referred to as the “mixing and absorbing zone” (column 4, line 8 of Jewell et al), the “mixing section” (column 4, line 24, column 4, lines 36-37, and column 4, line 39 of Jewell et al), the “mixing zone” (column 4, line 56 of Jewell et al), the “mixing and vaporizing zone” (column 4, line 74 of Jewell et al) and the “confined mixing zone” (column 5, lines 8-9 of Jewell et al). The vaporizing section of the coking zone is also depicted in Figure 3 of Jewell et al.

The hot coke particles are introduced into the upper end of the vaporizing section partition (24) through branch lines (28). The residual oil is introduced into the upper end of the vaporizing section partition (24) through line (17) and spray head (25), and the spray of the residual oil is directed into the hot coke particles to “effect intimate contact” of the hot coke and oil (column 3, line 70 and column 4, lines 25-26 of Jewell et al). The vaporizing zone is configured to “promote intimate mixing” of the hot coke particles and the residual oil (column 4, line 27 of Jewell et al). The “mixing” of the hot coke particles and the residual oil within the vaporizing section of the coking zone may be assisted by introducing extraneous gas directly into the “mixing section” (column 4, lines 34-37 of Jewell et al), producing a “swirling movement” of the hot coke particles and the residual oil droplets whereby there is “intimate contact” of the hot

coke particles and the residual oil within the vaporizing section (column 4, lines 41-44 of Jewell et al).

The hot coke particles with residual hydrocarbons absorbed thereon are removed from the vaporizing section partition (24) via exit (31) which is located at the bottom of the vaporizing section partition (24).

The second stage of the coking process is described extensively at column 5, line 14 to column 6, line 30 of Jewell et al. The soaking section of the coking zone is depicted in Figure 1 and Figure 2 of Jewell et al. The hot coke particles with residual hydrocarbons absorbed thereon are precipitated upon the fluid bed (21) after being discharged from the exit (31) of the vaporizing section partition (24). The fluid bed (21) of coke particles moves laterally toward a withdrawal passageway (32), providing a uniform residence time of the coke particles in the fluid bed, thereby facilitating a completion of the coking of the residual hydrocarbons which are absorbed on the hot coke particles.

Based upon both the geometry and the manner of operation of the vaporizing section (i.e., mixing section) and the soaking section, it is clear that the two stage coking process described in Jewell et al consists of a first stage which is performed in a well mixed flow type fluid bed reactor (24) and a second stage which is performed in a plug flow type fluid bed reactor (21).

Referring to page 3, line 33 to page 5, line 20 of the Specification, it is therefore respectfully submitted that Jewell et al is essentially directed at a fluid coking process as described therein which includes initial processing in a well mixed flow type fluid bed reactor followed by processing in a stripping section which includes a plug flow type fluid bed reactor.

As a result, the process described in Jewell et al will be subject to the same limitations as other processes (such as the fluid coking process) which are conducted in a well mixed flow type fluid bed reactor. Specifically, the vaporizing section partition (24) will need to be greatly oversized in order to limit the amount of liquid feed material which is lost to short circuiting and/or the operating temperature of the vaporizing section will need to be increased in

order to increase the reaction speed. In any case, a compromise will be required between the capital cost of the reactor and the yield and quality of the liquid products obtained from the liquid feed material.

In other words, the vaporizing section (i.e., mixing section) in Jewell et al represents a “bottleneck” in the coking process described in Jewell et al.

The limitations of the process described in Jewell et al are further exacerbated by the requirement in Jewell et al that the hot coke particles which are discharged from the exit (31) of the vaporizing section partition (24) must be “sufficiently dry” so that they can be fluidized by the aerating and stripping gas in the fluid bed (21) (column 3, lines 42-48 of Jewell et al) and by the requirement that the hot coke particles “remain in a relatively dry non-adhering condition” in which they may be maintained as a dense free-flowing, fluidized mass in the fluid bed (21) (column 4, lines 47-53 of Jewell et al).

It is respectfully submitted that in order for relatively dry non-adhering coke particles to be produced in the vaporizing section of the coking zone in Jewell et al, a very high conversion rate of the liquid feed material must be achieved in the vaporizing section. As a result, the requirement in Jewell et al that “dry” hot coke particles be produced in the vaporizing section will serve as an additional limitation affecting the design of the vaporizing section in Jewell et al, and will result in further difficulty in achieving an acceptable compromise between the capital cost of the reactor and the yield and quality of the liquid products produced from the liquid feed material.

In contrast, the process which is explicitly claimed in independent Claim 26 does not include processing in a well mixed flow type fluid bed reactor. Instead, the liquid feed material is introduced directly to a plug flow type fluid bed and separately from the solid particles so that the residence time of all of the liquid feed material in the reactor can be carefully controlled, thereby facilitating a lower operating temperature in the reactor (resulting in increased yield and quality of liquid products) and a smaller reactor size in comparison with the reactor required in Jewell et al.

It is therefore respectfully submitted that the following limitation:

“Jewell does not disclose “introducing the liquid feed material *directly* to the fluid bed...at a feed zone located between the upstream horizontal position and the downstream horizontal position.”

as explicitly claimed in independent Claim 26 IS of patentable consequence because of the inherent limitations of the vaporizing section of the process of Jewell et al which are not present in the process which is explicitly claimed in independent Claim 26.

Conclusions

In summary, it is respectfully submitted that the rejection of independent Claim 26 as being unpatentable over Jewell et al is overcome by the above remarks. In particular, it is respectfully submitted that the limitations contained in independent Claim 26 which are acknowledged in the Office Action not to be disclosed in Jewell et al ARE of patentable consequence.

It is therefore respectfully submitted that independent Claim 26 is allowable and allowance of independent Claim 26 is respectfully requested.

Dependent Claims 2-25 depend directly or indirectly from independent Claim 26. It is respectfully submitted that these dependent Claims are allowable for the distinctions defined therein as well as for the reasons supporting the allowability of Claim 26. Accordingly, allowance of dependent Claims 2-25 is also respectfully requested.

In view of the foregoing remarks, it is submitted that this Application is in condition for allowance and allowance of all of Claims 2-26 is respectfully requested.

Respectfully submitted,

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